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To consider solutions to the problem of providing better instruction for more students at less cost in the face of an increasing demand for education beyond the secondary level, Rensselaer Polytechnic Institute, in 1956, organized Project "Reward," an experiment to find more effective and efficient ways of teaching. The project provides services to faculty and administration, and coordinates, when needed, the separate instructional research efforts of the faculty. Since the key element in providing better instruction to more students at less cost seems to be increased instructional productivity, the article describes Rensselaer's efforts toward this end, namely: The processing of instructional cost-analysis data; the development of multimedia instructional methods and materials, including closed-circuit television and films produced on campus; the consultations of faculty and project staff concerning instructional materials, equipment, classroom facilities, experimental projects; and the dissemination of information on experimental efforts at Rensselaer and elsewhere.																					
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Project "Reward"

A Program of Institutional Research To Increase Instructional Productivity

PHILIP H. TYRRELL

A ONE-DIMENSIONAL treatment of Rensselaer Polytechnic Institute's Project "Reward"—what it is, what it does—would not convey a really meaningful picture to anyone because there would be no frame of reference in which to place it. The frame is necessary in order for anyone to understand the several dimensions of its activity.

Therefore, I shall explain (1) what the project is (very briefly), (2) the problem it seeks to alleviate, and an analysis of the factors involved, (3) the concepts in terms of which it operates, (4) what it does, and how and through whom it gets things done, (5) what its results have been thus far, and (6) what the future needs from it and similar agencies. I hope this procedure will provide the "Why," as well as the "What," "How," and "Who" of Project "Reward's" existence. Since it is now in only the third of what may be an indefinite number of phases, this is a progress report, not a final one.

Project "Reward" is both an idea and an agency. As an idea, it is the over-all progressive attitude at Rensselaer toward experimentation to find more effective and efficient ways of teaching. This involves research aimed at the continuing improvement in quality of what we believe to be already good instructional programs, at a cost less than that to be expected for such improvement. As an agency, the project provides services to faculty and administration, and coordinates, when needed, the separate instructional research efforts of the faculty.

The problem

The problem which the project seeks to alleviate is one that everybody knows well but which no one, until recent years, has done anything about; namely, how to provide, in the face of a vastly increasing demand for education beyond the secondary level, better instruction to more students at less cost.

We all know the urgency of this problem. One prediction of the total enrollment of full-time students in higher education in 1970 is 4,504,500, as compared with 2,551,723 in 1959.¹ We also know how fast new information is developing in every discipline. The problem, then, is easily stated; however, its analysis and solution are more difficult.

If "a problem is a situation which lacks a ready-made answer based on past experience and demands that definite action be taken to secure a desired outcome,"² what is a reasonable attack on the problem at hand?

Our attack at Rensselaer, begun in 1956, has been, first, to gain some experience pertinent to the problem, and, second, to implement a plan of action timed in accordance with our growing experience and our resources, all with the inspiration and vision of our leader-

¹ *Higher Education and National Affairs*, Bulletin issued by American Council on Education, March 31, 1960, p. 9.

² *Air Science 3* (Maxwell Air Force Base, Montgomery, Ala.: Air University), II, 2. (This book has been used as a text for a course entitled "Problem-Solving Techniques" at Air University.)

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ship—in this case, our trustees, president, and provost. To this end, we have developed a program of activities designed to serve the instructional programs of Rensselaer as a whole, with special emphasis upon assisting those individual faculty members who wish to explore new instructional methods and materials. Faculty participation in this program is, of course, absolutely voluntary. No dean or provost at Rensselaer has ever forced an instructor to change his teaching methods.

Concepts relevant to the problem

From our progress thus far in attacking the problem, we can say that we believe the key element in providing better instruction to more students at less cost is *increased instructional productivity*. If we adapt Peter F. Drucker's definition of economic productivity³ to the field with which we are concerned, then *instructional productivity* can be described as the balance between all known factors of instruction that will give the greatest output of a desired quality for a given effort (or cost). At Rensselaer, we believe that this balance can be best determined by objective cost analysis, plus our most informed assumptions about, and our most reliable attempts to measure, quality.

Now, lest I generate some misconceptions about the area in which Project "Reward" operates, I wish to define some terms that we ordinarily use very loosely, namely, training, instruction, and education. Although many definitions of these concepts are available, I prefer the following:

1. *Training*. "Training is the management of personnel improvement."⁴ "Per-

sonnel" may refer to employees or students, depending on the organization. Training aims at such objectives as proficiency in skills and the development of right attitudes for specific environments. The concept of training is too limited to be the area of emphasis of Project "Reward," and will not be considered further in our discussion.

2. *Instruction*. Instruction is a creative process of developing in others "knowledge, information, attitudes, skills, understandings, appreciations, and behaviors."⁵ In addition, "instruction means a pre-planned, deliberate selection and arrangement of situations so as to stimulate learner interaction. The result of this interaction is experience, which is intended to help the individual change his patterns of response in a predetermined, prescribed direction considered desirable by those responsible for the instruction."⁶ We may summarize this definition by saying that instruction is a process of "imparting knowledge, information, or skill to the student, especially by systematic methods."⁷ This is the area of emphasis to which Project "Reward" has confined its main effort.

3. *Education*. Definition of this term is important to a distinction we will need to make, in a moment, between education and instruction. Of the many definitions of education which exist, the following three are representative:

"All education is a search for talent, a development of humans to their full potential, and a means by which people can rise from an inherited caste in accordance with their abilities." This is a philosophical definition, stated by Harold

³ Drucker, *The Practice of Management* (New York: Harper & Bros., 1954), p. 41.

⁴ Charles Bish, "Bridging the Gap between Theory and Practice," Paper presented to the Institutes for Supervisors of Training of the General Electric Company, 1954.

⁵ Lindley J. Stiles, "Instruction," in *Encyclopedia of Educational Research* (3rd ed.; New York: Macmillan Co., 1960), pp. 710-14.

⁶ Charles F. Hoban and Edward B. van Ormer, *Instructional Film Research, 1918-1950*, Technical Report No. SDC 269-7-19 (Port Washington, L.I., N.Y.: Special Devices Center, 1951), chap. I, p. 3.

⁷ Stiles, "Instruction," *loc. cit.*

M. Groves,⁸ and based on the attitude reflected in the report of the Committee for the White House Conference on Education.

"Education, in a broad sense, refers to all those experiences, both planned and incidental, which the individual encounters and which contribute, in a large or small degree, to the modification and growth of his knowledge, abilities, attitudes, and other aspects of self-development. These experiences, interacting with his hereditary and natural potentialities, result in his being the kind of person he is now."⁹ Formal education is "directing or guiding an individual's learning so that he will develop socially useful forms of behavior."¹⁰ Hoban defines learning as "a process of individual discovery."¹¹

Another philosophical definition is by Thomas Henry Huxley, who, in 1868, wrote that "education is the instruction of the intellect in the laws of Nature, under which name I include not merely things and their forces, but men and their ways; and the fashioning of the affections and of the will into an earnest and loving desire to move in harmony with those laws."¹²

From these definitions we can see that "education" is a broad generic term which includes the specific process of instruction. Rensselaer, of course, aims at contributing to education in the broad sense; but, within Rensselaer, Project "Reward" aims specifically at contributing to the creative process of instruction.

⁸ Groves, "National Economy and Education," in *Encyclopedia of Educational Research* (3rd ed.; New York: Macmillan Co., 1960), pp. 917-22.

⁹ Hoban and Van Ormer, *Instructional Film Research, 1918-1950*, chap. I, p. 3.

¹⁰ *Ibid.*, chap. I, p. 3.

¹¹ Charles F. Hoban, "Research and Reality," *Audio-Visual Communication Review*, Winter 1956, p. 15.

¹² Huxley, "A Liberal Education, and Where To Find It," *Collected Essays*, Vol. III: *Science and Education* (New York: D. Appleton, 1914).

The distinction between education and instruction is very important when we use the concept of instructional productivity to attack the problem of providing better instruction to more students at less cost. The implications of this distinction have been stated by the provost of Rensselaer, Dr. Clayton O. Dohrenwend:

Experience shows that the complete educational process is difficult, slow, and capable of only limited acceleration. This makes it problematical that the educational process can be significantly speeded up. Here we are dealing with the human mind and its ability to learn, retain, and correlate information. The educational process, although it is properly strengthened by the school, is life long. However, instruction, one of the main mechanisms through which education is achieved, is not subjected to the same limitations. Instruction can be speeded up and can be accomplished on a mass production basis.¹³

This belief that the instructional process can be altered for the better—time-wise, costwise, and qualitywise—is the premise behind the efforts of Project "Reward." The implementation of planned action, based on this belief, is the essence of increased instructional productivity. Note that we are altering only one element in the complete lifelong educational process, which contains numerous elements, many having as much importance as instruction.

Now that we have stated the problem and examined the concepts which constitute the project's theoretical orientation, let us inspect the specific program and activities of the project.

The Project "Reward" program

In addition to what has already been said, Project "Reward" can also be de-

¹³ Dohrenwend, "An Introduction to the Problem," Unpublished proceedings of Seminar on Reduction of Costs of College Instruction, held at Rensselaer Polytechnic Institute, February 1959.

scribed as an institutional research program. What is institutional research in a college?

For our present purposes, I should like to define an institution as a formal organization, which Ordway Tead describes as "a combination of the necessary human beings, equipment, facilities and appurtenances, materials and tools, assembled in some systematic and effective coordination, in order to accomplish some desired and defined objective."¹⁴ Although "desired and defined" objectives of institutes and colleges evolve and change and thereby are a perennial topic of long-range planning, they always include the objective of effective instruction.

For the record, let us also define "research"—in this case, "applied research." It is "a method of studying problems whose solutions are to be derived partly or wholly from facts. The facts dealt with in research may be statements of opinion, historical facts, those contained in records or reports, the results of tests, answers to questionnaires, or experimental data of any sort."¹⁵

Therefore, summarizing our interpretations of instruction, institutions, and research—all with respect to Project "Reward"—we may say that the project, besides being an idea, is an agency that bases its operations on the methodical study of problems that are concerned with the process of imparting knowledge, information, or skills to students within a formal organization which has the effectiveness of this process as one of its continuing objectives.

Now, let us look at specific activities that are concerned with our institutional research.

¹⁴ Tead, *The Art of Administration* (New York: McGraw-Hill Book Co., 1951), p. 10.

¹⁵ Earl Bennett South, *A Dictionary of Terms Used in Measurements and Guidance* (New York: Psychological Corporation, 1939), p. 69.

Project "Reward" activities

The first activity is the processing of instructional cost-analysis data gathered by means of a Faculty Activities Report, data which finally end up in tabular form—more than thirty tables for each year's analysis. Faculty members submit these reports each semester, and we now have data covering the last five years. One product of each year's analysis is the unit cost of instruction, in three forms: per student credit hour; student contact hour; and instructor contact hour, by departments. A second product is percentages of classroom utilization. The processed data are interpreted by academic administrative officers to ascertain trends and to identify critical factors in the operation of separate programs. The annual analyses have also become a means of measuring, in terms of cost, the results of instructional experimentation, for example, in class size and in the use of closed-circuit television. Administrators find the data in these analyses vital to the decision-making process.

The second area of activity in which we engage—and it is by far the most glamorous—is the development of multimedia instructional methods and materials. This activity is based on the premise that, with consultation and production services provided, the teacher can increase his own capabilities and that greater student learning will result. You may recall Henry Adams' statement that "a teacher affects eternity; he can never tell where his influence stops."¹⁶ We want every teacher's influence to become as effective as possible, not only through the growing wisdom of experience but also through better methods and materials for communicating what he knows. Increasing staff capabilities and effectiveness is an aspect of the quality factor in instructional productivity.

During the last four years, we have

¹⁶ *The Education of Henry Adams*.

built a multimedia production program, as follows:

1. *Instructional films.* More than thirty years of film research indicates that teaching films are effective in communicating facts, demonstrating procedures, and visualizing concepts. Yet very few good films exist on a level above the secondary school. We have acquired film production personnel and professional equipment and produced, thus far, ten films in the following fields: Chemistry, civil engineering, engineering drawing, language and literature, mechanical engineering, mechanics, and physics. During the next two years, we expect to double our film production annually. All of our films are produced, of course, in cooperation with faculty.

2. *Closed-circuit television.* During 1957-58, we helped the staff of our Department of Mechanics apply CC-TV to one of their courses, Strength of Materials Laboratory. This meant the development of numerous scripts; selection, acquisition, and installation of equipment; and the careful programming of subject matter to utilize the advantages of the TV close-up shot. We conducted a controlled experiment on this type of teaching versus the conventional and found it, in several ways, to be superior. Since then, we have used this medium for teaching the course. We also have CC-TV installations, for purposes of magnification, in our Departments of Metallurgical Engineering and Physics.

3. *Other photographic aids and artwork.* In addition to studio and location still photography, resulting in hundreds of slides and prints each year, we are currently producing—through a method of combining artwork and either photography or the diazo process—many large transparencies for use with the overhead projector. This type of projection often eliminates the chalkboard.

By developing these methods and materials, teachers are able vastly to in-

crease their capabilities and, thereby, they promote for each student that "process of individual discovery" by helping him to see and understand, through many media, the subject he is studying. If "all experience is an arch, to build upon,"¹⁷ as Henry Adams also said, then the greater number of truly meaningful experiences—through the senses and the mind—that we can give the student, the better he can build his future. The effective sharing of such experiences between teacher and student builds an immediate teacher-scholar to student-scholar relationship which is not greatly different from that which we are told Mark Hopkins enjoyed on his famous log, although we may mediate these experiences by film, TV, mechanisms for independent study, or, in the future, by devices not yet invented. Behind the programming of any device, there is the teacher.

The third area of Project "Reward" activity is consultation. Faculty consult with us on instructional materials, equipment, classroom facilities, and the design of experimental projects. All major, and many minor, production efforts are preceded by lengthy consultation.

In connection with consultation and production, I should like to interpose some comments on how Project "Reward" helps to initiate experimental efforts on the campus. For example, we "primed the pump" when we assisted our Department of Mechanics with their CC-TV teaching installation. This application of TV led this department to design, and attract funds for, the renovation of a traditional lecture hall into a modern pilot auditorium-studio, of which the outstanding feature is a "communication wall" designed especially for multimedia presentations. This facility enables an instructor to present, sequentially or simultaneously, four rear-projected im-

¹⁷ *Ibid.*

ages (motion picture, TV, and 2"x2" and 3 1/4"x4" slides). Concurrently, we interested our School of Architecture in undertaking, with outside support, an investigation into the design of auditorium-studio facilities for engineering education. So now we have an experimental classroom in operation and a design studies program near conclusion (as of January 1961), both of which are preparatory to the building of a large auditorium-studio or its equivalent in Rensselaer's new Science Center.

The fourth area of project activity is the dissemination of information. Our newsletter, *Toward More Effective Teaching at Rensselaer*, published each semester, has elicited a generous response from our faculty, whom it seeks to inform about one another's experimental work; it has also attracted interest from diverse parts of the educational community at large. (You will find some of its articles listed in *Reporter* and in other publications of the U.S. Office of Education.) In addition, we collect reports on experimental work at other schools and circulate them among our faculty; we want to learn from others as well as to share freely what we have to offer.

Greatly summarized, these are the avenues we have found to be most promising for us in achieving improved instruction at reduced cost.

Sample results

Project "Reward" has moved through Phase I (the preliminary investigation of what needed to be done), and through Phase II (exploratory work and preliminary evaluation of selected experimental efforts). It is now in Phase III (the development of programmed experimentation having the acknowledged status of institutional research). Details of later phases cannot be outlined at this time. However, we do feel certain that,

with the vast technical developments which surely lie ahead of us and with the nature of teachers and teaching being what each is, we will never arrive at standardization of the instructional process nor of those personalized activities which provide service to our faculty. Instruction will continue to be creative and, I hope, intimate, though the intimacy may be of a different kind than we now know.

The following sample results are based primarily on Phase II—preliminary evaluation of selected experimental efforts:

1. Since 1957 we have held the line on the unit cost of instruction, although faculty salaries have been raised and our students are benefiting from an improved educational experience. Unit costs have remained fairly constant.

2. The efficiency of our classroom utilization has increased. We carry the same instructional load we did several years ago, but now with fewer classrooms than previously—the extra rooms being converted for other uses (laboratories and offices). This increase in efficiency is due to improved central scheduling procedures and to the larger classes we now have.

3. In a controlled experiment in our Department of Mechanics—an experiment whose results we believe to be representative also of several other departments—we found that class size is not as important to the effectiveness of instruction as is the teaching method used. Three teaching methods were compared in this experiment: the small section method, the lecture-discussion method, and an experimental approach used with large classes.

According to Professor R. H. Trathen, who conducted the experiment, the good student did well regardless of teaching method or the teacher. The average student, on the other hand, benefited by being assigned to an experimental sec-

tion of 90 to 100 students.¹⁸ Results of this experiment led the department to adopt the large-section system for teaching all its courses, with important implications. For example, in the fall of 1958, a typical semester, 100 weekly instructor contact hours would have been required to handle the enrollment in two selected courses if students had been assigned to small sections. By using large sections, only 23 instructor contact hours were required. Standards of student achievement were not sacrificed.

In this department, also, a controlled experiment on teaching a laboratory course by means of CC-TV was conducted during the spring of 1958. Quantitatively measured, the achievement of TV students equaled that of those taught conventionally. Important by-products of this investigation were: communication of information by TV was more uniform from section to section than that provided by instructors in conventional laboratory classes; and, from the student's point of view, the TV method was slightly more efficient than the conventional method in the utilization of laboratory time.¹⁹

4. Since our films have been used thus far only as supplementary aids to instruction, we have had little opportunity to measure their effect quantitatively, mainly because we have not yet produced an entire series on one subject. Soon we will be able to do this, in what will be a controlled experiment in teaching Graphics II, under a grant from the U.S. Office of Education. However, among our finished films are two in what will be a series of ten on advanced sur-

veying. Professor G. R. Shaw, who teaches this subject, describes the results of using the first film: *all* students viewing the film reported that it helped them to understand the procedures shown, and 34 percent of the students reported that they had been helped to a high degree by the film.²⁰ Other of our films, even as aids, have saved professors' time by replacing conventional laboratory demonstrations which usually require lengthy set-up procedures.

5. In the area of independent study, a sample result of experimentation involved our Department of Chemistry. With the objective of increasing the student's responsibility for his own education, the entire subject matter of a course in quantitative analysis was given to students in eight lectures and two film presentations during the first five weeks of the course. The laboratory part of the course was not changed. Study sessions and quizzes were scheduled, but attendance was voluntary. Professor L. G. Bassett, who taught the course, states that student achievement did not suffer, fewer contact hours of a senior professor were required, and student reaction was good.²¹

These are, of course, sample results, but representative of Rensselaer's instructional experimentation. They are all related either to the cost or the quality, or both, of instruction, and a balance of these factors is what we mean by instructional productivity.

Synthesis for the future

When we speak of the future, it is difficult to limit one's remarks to the instructional process. But I shall try to do so,

¹⁸ Trathen, "Two Years of Experimental Work on Various Teaching Methods and Class Sizes," *Journal of Engineering Education*, February 1960, p. 385.

¹⁹ Joseph F. Throop, Lewis T. Assini, and George W. Boguslavsky, *The Effectiveness of Laboratory Instruction in Strength of Materials by Closed-Circuit Television* (Troy, N.Y.: Rensselaer Polytechnic Institute, 1958).

²⁰ Shaw, "Instructional Films in Surveying Education," *Surveying and Mapping*, June 1960, p. 192.

²¹ Bassett, "Increasing the Student's Responsibility for His Own Education," in *Case Book: Education Beyond the High School* (Washington: Division of Higher Education, U.S. Office of Education, June 1958), Vol. I, Case No. 36.

because as Alfred North Whitehead once said, "in education, as elsewhere, the broad primrose path leads to a nasty place!"²²

In looking forward, we must start where we are now. We must find more solutions to our present and continuing problem: how to provide better instruction to more students at less cost. This problem will probably always be with us, but its critical factors will change and our solutions must keep pace with the changing aspects of the problem. And there will be many other problems. We must learn to recognize them. We must develop procedures for asking the right questions. Undoubtedly, this is a task for institutional research programs.

Just to raise some questions, I have formulated, at the risk of vast oversimplification, a few of the many elements in an instructional environment. Combinations of various elements, or components, may be called "systems," in that the components and their attributes exhibit relationships with one another. It is helpful, also, to think of these systems as "open," because they exchange energy or information with their environment.²³

What one includes in a system depends upon the specific problem to be investigated. For example, in exploring an experimental program of independent study, some of the interacting elements of one system might be a professor, selected students, a structured area of knowledge, and specialized learning aids, each having identifiable attributes. Not only would this system be maintained and developed (in this case, for a specified length of time), but the combination of components, plus each one's relation-

ships with each other one, all acting dynamically, would influence the instructional environment as a whole and other open systems within this environment. Obviously, this kind of interaction promotes feedback and reorganization. We may, of course, have subsystems and larger environments.

It is of interest to observe, in connection with instructional productivity, that there normally exists within an instructional environment a control mechanism, in itself an open system, for evaluating the quality and cost of instruction. Similarly, in the larger educational environment, a comparable control mechanism makes possible evaluation of quality and cost from a more comprehensive viewpoint.

Using the open-systems approach as a procedure for identifying and analyzing problems anticipated in the future, what are some of the right questions for us to ask now? Here are a few suggestions:

1. As we introduce new, and delete old, elements in the instructional environment, what changing roles will the teacher play?

2. Concurrently with any change, how can we learn better to evaluate what we do? How can we learn better to make assumptions about the future and learn better to choose a future course of action? How can we improve the decision-making process in education?

3. In accomplishing the above, how can we guarantee the freedom of the teacher? If "the teacher affects eternity," he must not lose, but gain, in influence as an intellectual leader.

4. Lastly, but basic to every consideration, what do we want to achieve—tomorrow, in 1970 or 1980, in 2000—by this process of education, of which instruction is one part? Objectives surely change, as human conditions change. How do we formulate the right objectives?

²² Whitehead, *The Aims of Education and Other Essays* (New York: Macmillan Co., 1929), p. 7.

²³ A. D. Hall and R. E. Fagen, "Definition of System," *Yearbook of the Society for General Systems Research* (Ann Arbor, Mich.: The Society), I, 23.

This may sound too philosophical. But we have the talent to answer the minor questions: Shall we introduce TV or not? How do you construct a better examination? How do you keep a curriculum up to date? How do you build appropriate facilities? The real challenge of the future is none of these. But the challenge does involve the complex interaction of students, teachers, and the community. It also involves the expansion of knowledge and the greatly human conditions of wealth, poverty, and physical and spiritual sickness and health.

These observations have already led us far beyond instruction, and, I am

afraid, have started us down the "broad primrose path." It is, therefore, time to stop. The future is an open question.

However, we all belong to some part of the educational environment. Each of us has ever-maturing goals and standards for ourselves as members of the teaching profession. Programs of institutional research, such as Project "Reward," can often help us to discover and to share new dimensions in the teaching-learning process, thereby assisting education in accomplishing whatever present and future tasks it elects to undertake in order to serve effectively the needs of man.